General

Guideline Title

Effectiveness of preanalytic practices on contamination and diagnostic accuracy of urine cultures: a Laboratory Medicine Best Practices systematic review and meta-analysis.

Bibliographic Source(s)

LaRocco MT, Franek J, Leibach EK, Weissfeld AS, Kraft CS, Sautter RL, Baselski V, Rodahl D, Peterson EJ, Cornish NE. Effectiveness of preanalytic practices on contamination and diagnostic accuracy of urine cultures: a Laboratory Medicine Best Practices systematic review and meta-analysis. Clin Microbiol Rev. 2016 Jan;29(1):105-47. [69 references] PubMed

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

Definitions for the ratings of overall strength of evidence and recommendation categories are provided at the end of the "Major Recommendations" field.

Conclusions and Recommendations

A summary of the findings of this evidence-based review of urine culture preanalytics can be found in Table 15 in the original guideline document. Conclusions are categorized as "recommended," "not recommended," or "no recommendation for or against" and refer to studies of urine collected by noninvasive methods:

1. No recommendation for or against is made for delayed processing of urine that is stored at room temperature, refrigerated, or preserved in boric acid due to insufficient evidence. Data from nine studies receiving a "fair" quality rating suggest that both refrigeration and boric acid adequately preserve urine specimens for up to 24 hours prior to their being processed. Furthermore, data from three studies receiving a "fair" quality rating suggest that urine held at room temperature for more than 4 hours should not be processed due to overgrowth of both clinically significant and contaminating flora. However, because the overall strength of the body of evidence was rated as low, no recommendation for or against can be made due to insufficient evidence. This does not preclude the use of refrigeration or chemical preservatives in clinical practice. It does indicate, however, that more systematic studies evaluating the utility of these measures are needed.
2. If noninvasive collection is being considered for women, midstream collection with cleansing is recommended, but no recommendation for or against is made for midstream collection without cleansing due to insufficient evidence. Data from two studies, including one randomized controlled trial receiving a "good" quality rating and three studies receiving a "fair" quality rating, show that contamination rates are similar

between specimens obtained by midstream collection with and without cleansing. The overall strength of this body of evidence was rated as high. However, whether midstream collection can be routinely used in place of straight catheterization is unclear. Data from three studies, two with a quality rating of "fair" and one with a rating of "good," suggest that clean-catch midstream urine collection is highly accurate for diagnosing urinary tract infections (UTIs) in women; however, because the overall strength of this body of evidence was rated as low, no recommendation for or against can be made.

3. If noninvasive collection is being considered for men, midstream collection with cleansing is recommended and collection of first-void urine is not recommended. No recommendation for or against is made for collection of midstream urine without cleansing due to insufficient evidence. Data from two studies, one with a quality rating of "good" and one with a rating of "fair," found a large reduction in the level of contamination in specimens obtained by midstream collection with cleansing compared to the level of contamination after collection of first-void urine. This body of evidence was rated as high. Although data from one study rated as "good" quality found no difference in contamination between midstream urine collected with and that collected without cleansing, imprecision was largely due to the small event size, and no recommendation can be made as to which method is superior. Whether midstream collection can be used routinely in place of straight catheterization or suprapubic aspiration is unclear. Data from two studies receiving a "fair" quality rating suggest that midstream collection with cleansing is highly accurate for the diagnosis of UTIs in men; however, because the overall strength of the body of evidence was rated as low, no recommendation for or against can be made.
4. If noninvasive collection is being considered for children, midstream collection with cleansing is recommended and collection with sterile urine bags, from diapers, or midstream without cleansing is not recommended. Data from six studies, two with a quality rating of "good" and four rated as "fair," found large reductions in contamination in midstream clean-catch urine specimens compared to contamination after other noninvasive methods of collection. This body of evidence was rated as high. Whether midstream collection with cleansing can be routinely used in place of catheterization or suprapubic aspiration is unclear. Data from eight studies, two with a quality rating of "good" and six rated as "fair," suggest that midstream collection with cleansing is accurate for the diagnosis of UTIs in infants and children and that midstream collection with cleansing has higher average accuracy than sterile urine bag collection (data for diaper collection was lacking). However, the overall strength of evidence was low, as multivariate modeling could not be performed; thus, no recommendation for or against can be made due to insufficient evidence.

Definitions

Overall Strength of Evidence Ratings*

The Expert Panel rates the overall strength of the body of evidence in support of the practice and it is categorized as High, Moderate, Suggestive, and Insufficient as defined.

High: Adequate volume of consistent evidence of substantial healthcare quality impact from studies without major limitations.

Moderate: Some evidence of consistent substantial healthcare quality impact from studies without major limitations; OR an adequate volume of consistent evidence of moderate healthcare quality impact from studies without major limitations.

Suggestive: Limited evidence of moderate healthcare quality impact from a small number of studies without major limitations; OR the quality of some studies' design and/or conduct is limited.

Insufficient: Any estimate of an effect on healthcare quality impact is too uncertain.

*These rating categories have their basis in the work of Guyatt et al.; they were modified to reflect both the quality of the evidence and effect size observed, rather than attempting to anticipate the impact of future potential evidence. The modified definitions for these categories are modeled after the U.S. Preventive Services Task Force.

Recommendation Categories

Recommend: High or moderate for improving healthcare quality. The practice should be identified as a "best practice" for implementation in appropriate care settings, taking into account variations and applicability in implementation and/or care settings.

No recommendation for or against: Suggestive or insufficient. A potentially favorable impact on healthcare quality is not of sufficient size, or not sufficiently supported by evidence to indicate that it should be identified as a "best practice" for implementation in appropriate care settings.

Recommend against: High or moderate for adversely affecting healthcare quality. The practice should not be identified as a "best practice" for implementation because it is not likely to result in more good than harm.

Clinical Algorithm(s)

None provided

Scope

Disease/Condition(s)

Urinary tract infection (UTI)

Guideline Category

Diagnosis

Technology Assessment

Clinical Specialty

Family Practice

Infectious Diseases

Internal Medicine

Obstetrics and Gynecology

Pathology

Pediatrics

Urology

Intended Users

Advanced Practice Nurses

Clinical Laboratory Personnel

Health Care Providers

Nurses

Physician Assistants

Physicians

Guideline Objective(s)

To identify and evaluate preanalytic practices associated with urine specimens and to assess their impact on the accuracy of urine culture microbiology

Target Population

Any patients who have urine cultures collected

Interventions and Practices Considered

1. Urine collection methods

    - Midstream collection of urine with cleansing
    - Midstream collection of urine without cleansing (no recommendation for or against)
    - Collection of first-void urine for men (not recommended)
    - Collection with a sterile urine bag versus diaper collection for infants and children (not recommended
2. Immediate versus delayed processing of urine specimens
3. Storage and preservation of urine samples
    - Room temperature
    - Refrigeration
    - Boric acid

Major Outcomes Considered

- Contamination rates
- Diagnostic accuracy of urine culture

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Searches of Unpublished Data

Description of Methods Used to Collect/Select the Evidence

The review question addressed by this analytical review was as follows: "Are there preanalytic practices related to the collection, preservation, transport, and storage of urine for microbiological culture that improve the diagnosis and management of patients with urinary tract infection?" Components of the preanalytic phase of urine culture were studied in the context of an analytical framework for factors affecting specimen contamination and diagnostic accuracy, depicted in Figure 1 in the original guideline document. The population, intervention, comparison, and outcome (PICO) elements are as follows.

- "Population" is any patients who have urine cultures collected.
- "Intervention" is clinical practice.
- "Comparison" is made of
    - Immediate versus delayed processing of urine held at room temperature
    - Immediate versus delayed processing of refrigerated urine or urine preserved in boric acid
    - Midstream clean-catch collection of urine without cleansing versus with cleansing (men and women)
    - Midstream clean-catch collection of urine without cleansing versus with cleansing versus collection with a sterile urine bag versus diaper collection for infants and children
- "Outcomes" are the results of determining the contamination rate and the diagnostic accuracy of urine culture.

Specific practices involving the preanalytic phase of urine culture covered in this evidence-based review were addressed by asking the following eight clinical questions.

1. What is the difference in colony counts when comparing immediate versus delayed processing of fresh urine stored at room temperature after collection?
2. What is the difference in colony counts when comparing immediate versus delayed processing of urine kept refrigerated or preserved in boric acid?
3. What is the difference in contamination rates between midstream urine collected with cleansing versus without cleansing in women being

tested for a urinary tract infection (UTI)?

4. What is the diagnostic accuracy of midstream urine collected with or without cleansing compared to bladder catheterization for the diagnosis of UTI in women?
5. What is the difference in contamination rates between midstream urine collection, with or without cleansing, and first-void collection in men?
6. What is the diagnostic accuracy of midstream urine collected, with or without cleansing, compared to that of bladder catheterization or suprapubic aspiration for the diagnosis of UTI in men?
7. What are the differences in contamination rates between midstream collection with cleansing, midstream collection without cleansing, and sterile urine bag or diaper collection in children?
8. What is the diagnostic accuracy of midstream clean-catch, sterile urine bag, or diaper collection compared with that of suprapubic aspiration or catheterization for the diagnosis of UTI in children?

The search for studies of practice effectiveness was conducted to identify those with measurable outcomes collected to the rigor of review requirements. With input from the expert panel and assistance of a research librarian at the Jesse Jones Library at the Texas Medical Center in Houston, TX, a literature search strategy and set of terms were developed. A search of three electronic bibliographic databases (PubMed, SCOPUS, and CINAHL) for English language articles published between 1965 and 2014 was conducted. In addition, hand searching of bibliographies from relevant information sources was performed. All search results were catalogued and maintained using a Web-based, commercial reference software package (RefWorks; ProQuest LLC, Ann Arbor, MI). Finally, solicitation of unpublished quality improvement studies was attempted by posting requests for data on both the Laboratory Medicine Best Practices Web site (https://wwwn.cdc.gov/futurelabmedicine/) and two listservs supported by the American Society for Microbiology: clinmicronet (http://www.asm.org/index.php/online-community-groups/listservs) and DivCNet (http://www.asm.org/division/c/divcnet.htm).

The search contained the following medical subject headings (MESH) and key text words: "urinary tract infections" (MESH) OR UTI (text word) OR urinary tract infect* (text word); "urine/analysis" (major) OR "urine/microbiology" (major) OR "urinalysis" (MESH); "specimen handling" (major); "preservation, biological" (MESH) OR preservation, biological (text word) OR "boric acids" (MESH) OR boric acid (text word) OR boric acid/borate (text word) OR boric acids (text word) OR "refrigeration" (MESH) OR refrigeration (text word) OR preserv* (text word); storage (text word); "time factors" (MESH) OR "transportation" (MESH) OR transport time (text word) OR delay (text word) OR time delay (text word) OR time factor (text word) OR timing (text word); "urine specimen collection" (MESH) OR urine specimen collection (text word) OR "catheters, indwelling" (MESH) OR catheters, indwelling (text word) OR "urinary reservoirs, continent" (MESH) OR urinary reservoirs, continent (text word) OR "urinary catheterization" (MESH) OR urinary catheterization (text word) OR "intermittent urethral catheterization" (MESH) OR intermittent urethral catheterization (text word) OR clean voided (text word) OR midstream (text word) OR midstream (text word) OR midstream (text word) OR foley (text word) OR suprapubic (text word); and "bacteriological techniques" (MESH) OR bacteriological technique (text word) OR bacteriological techniques (text word) OR "microbiological techniques" (MESH) OR microbiological technique (text word) OR microbiological techniques (text word).

Titles and abstracts were initially screened by the review coordinator, with assistance from the expert panel when necessary, to select studies for a full review. A study was included if it was considered likely to provide valid and useful information and met the PICO criteria previously discussed. Specifically, these inclusion criteria required that a study (i) address a defined population/definable group of patients, (ii) evaluate a specific intervention/practice included in this review, (iii) describe at least one finding for a relevant outcome measure (percent contamination, diagnostic accuracy) reproducible in comparable settings, and (iv) present results in a format which was useful for statistical analysis. Studies failing to meet the inclusion criteria (not considered to report a relevant practice, did not include a practice of interest, or did not present an outcome measure of interest) were excluded from further review.

Search results produced 5,092 unique documents that were initially screened for eligibility to contribute to evidence of effectiveness for practices defined by the eight clinical questions posed (storage and preservation of urine, collection of urine from women, collection of urine from men, and collection of urine from infants and children). There was no response to requests for unpublished data. The reduction of studies through the screening process is detailed in Figure 2 in the original guideline document.

Number of Source Documents

Forty-seven studies met the criteria for inclusion and were subjected to full abstraction and quality scoring. After an additional 12 studies were excluded because of insufficient quality scores, the remaining 35 were included in the statistical analysis: 10 studies on storage and preservation, 8 studies on collection from women, 3 studies on collection from men, and 14 studies on collection from infants and children.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Overall Strength of Evidence Ratings*

The Expert Panel rates the overall strength of the body of evidence in support of the practice and it is categorized as High, Moderate, Suggestive, and Insufficient as defined.

High: Adequate volume of consistent evidence of substantial healthcare quality impact from studies without major limitations.

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Suggestive: Limited evidence of moderate healthcare quality impact from a small number of studies without major limitations; OR the quality of some studies' design and/or conduct is limited.

Insufficient: Any estimate of an effect on healthcare quality impact is too uncertain.

*These rating categories have their basis in the work of Guyatt et al.; they were modified to reflect both the quality of the evidence and effect size observed, rather than attempting to anticipate the impact of future potential evidence. The modified definitions for these categories are modeled after the U.S. Preventive Services Task Force.

Methods Used to Analyze the Evidence

Meta-Analysis

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

Studies that cleared the initial screening were then abstracted and evaluated by the expert panel. For eligible studies, information on study characteristics, interventions, outcome measures, and findings of the study was extracted using a standardized form and assigned a quality rating derived from points awarded for meeting quality criteria. Individual quality ratings were based on four dimensions: study quality, practice effectiveness, defined outcome measure(s), and findings/results. The objective for rating individual study quality was to judge whether sufficient evidence of practice effectiveness was available to support inclusion in an overall body of evidence for evaluation of a best-practice recommendation (that is, a practice likely to be effective in improving one or more outcomes of interest in comparison to other commonly used practices).

The four study quality dimensions were rated separately, with a rating score assigned up to the maximum for a given dimension. The rating scores for all four dimensions were added to reach a single summary score reflecting overall study quality. A total of 10 points were available for each study. Reviewers assigned one of three quality ratings to each study: good (8 to 10 points), fair (5 to 7 points), or poor (4 points or less). Each study was reviewed and rated by two expert panel members to minimize subjectivity and bias. Any study ranked as poor by one reviewer but good by the second reviewer was assigned to a third expert panel member for resolution. More detail on the rating process of individual studies can be found elsewhere (see the "Availability of Companion Documents" field and additional references the original guideline document). Studies that did not meet a study quality rating of fair or good were excluded from further consideration. Data from published studies that passed a full review were transformed to a standardized, common metric according to Laboratory Medicine Best Practices (LMBP) methods. Summary data and quality scores for each publication included in this evidence-based review can be found in Appendix 3 in the original guideline document.

The study quality ratings and results from the individual studies for each clinical question were aggregated into bodies of evidence. The consistency of effects and patterns of effects across studies and the rating of overall strength of the body of evidence (high, moderate, low, suggestive, and insufficient) were based on both qualitative and quantitative analyses. Estimates of effect and the strength of the body of evidence were then used to translate results into one of three evidence-based recommendations (recommend, no recommendation for or against, recommend against). The ratings criteria are described in greater detail elsewhere (see the "Availability of Companion Documents" field).

While recommendations are based on the entire body of evidence, meta-analyses to generate summary estimates of effect were undertaken for

outcomes that provided sufficient data for measurements of diagnostic accuracy and contamination, i.e., proportions of specimens containing periurethral, perianal, epidermal, or vaginal flora. For the outcome of contamination proportion, summary odds ratios were calculated using Mantel-Haenszel methods in a random-effects model performed using Review Manager (RevMan) software version 5.0 (2008; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, DK). A contamination event was defined according to how individual studies defined contamination because definitions varied between studies. Wherever possible, contamination proportions were determined for the entire test population rather than a subset population (such as only among those individuals that tested negative for urinary tract infection). The I^2 statistic, which describes the percentage of variability in effects estimates due to statistical heterogeneity rather than sampling error, was used to assess between-study heterogeneity. For the outcomes of diagnostic accuracy, it was planned that point estimates of sensitivity and specificity would be summarized using the bivariate model when similar cutoff points were used; however, all models failed to converge due to a too-small number of study or sample sizes. Similarly, hierarchical summary receiver operator characteristic curves (HSROC) could not be generated because these models too failed to converge. Solutions for failure of convergence, including removing individual studies, were explored but did not improve convergence. Meta-analysis of diagnostic accuracy outcomes and curve fitting were not pursued further given the limitations of univariate methods. All work on summarizing diagnostic accuracy outcomes was performed using SAS software version 9.2 (2008; SAS Institute Inc., Cary, NC, USA) and the MetaDAS macro, version 1.3. Significant growth (i.e., a positive sample) was defined according to how each individual study defined significant growth because cutoff points tended to vary among studies. All other growth, including contamination and no growth, were considered nonsignificant growth (i.e., a negative sample), as this most closely reflects actual clinical practice. Two-by-two tables were used to determine sensitivity and specificity, and exact 95% confidence intervals were calculated.

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

The Centers for Disease Control and Prevention (CDC)'s Laboratory Medicine Best Practices (LMBP) "A-6 Cycle" systematic review methods for evaluating quality improvement practices was used for conducting this review. The methodology, reported in detail elsewhere (see the "Availability of Companion Documents" field), is derived from previously validated methods. It is designed to assess the results of studies of practice effectiveness that lead to best-practice recommendations that are evidence based. Using this method, a review coordinator and individuals trained to apply the LMBP methods conducted the systematic review with guidance from an expert panel. The expert panelists were chosen based on their breath of experience and perspective in clinical microbiology and laboratory management. Lastly, the team was supported by a statistician with expertise in evidence review methodologies and meta-analysis. The expert panel reviewed the results of the evidence review and drafted the evidence-based best-practice recommendations.

Rating Scheme for the Strength of the Recommendations

Recommendation Categories

Recommend: High or moderate for improving healthcare quality. The practice should be identified as a "best practice" for implementation in appropriate care settings, taking into account variations and applicability in implementation and/or care settings.

No recommendation for or against: Suggestive or insufficient. A potentially favorable impact on healthcare quality is not of sufficient size, or not sufficiently supported by evidence to indicate that it should be identified as a "best practice" for implementation in appropriate care settings.

Recommend against: High or moderate for adversely affecting healthcare quality. The practice should not be identified as a "best practice" for implementation because it is not likely to result in more good than harm.

Cost Analysis

Proper attention to the preanalytic phase of urine cultures should decrease the number of contaminated urine specimens processed by the laboratory. It may also decrease the time it takes for microorganism identification and susceptibility testing of pathogens in infected patients by reducing the number of recollected specimens. Both of these scenarios would likely reduce health care costs for both patients and institutions by reducing the time to appropriate targeted therapy and by making more-effective use of laboratory and hospital resources. However, no economic evaluation analyses were found for the studies covered in this review.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

The recommendations were approved by the Laboratory Medicine Best Practices Workgroup, consisting of 13 invited members with broad expertise in laboratory medicine, clinical practice, health services research, and health policy, as well as one *ex officio* representative from the Centers for Medicare and Medicaid Services.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Urine specimens that are appropriately collected, transported, stored, and preserved benefit patients by producing more-accurate culture results. In addition, such practices can provide benefit to the laboratory by allowing technologists to focus on the work-up of clinically significant pathogens rather than the growth of contaminants. Urine cultures are often a major component of the typical clinical microbiology workload; therefore, minimizing the processing of poor-quality urine specimens can allow the laboratory to focus its resources in a more cost-effective manner.

Potential Harms

Methods of collecting, storing, and preserving urine specimens for the diagnosis of urinary tract infections (UTIs) have a critical influence on culture results. Poorly collected or preserved specimens can become easily contaminated with perineal, vaginal, and periurethral flora, which can inhibit or obscure the presence of true urinary tract pathogens. Conversely, the use of high concentrations of boric acid as a preservative has been known to inhibit urinary pathogens such as *Escherichia coli* and *Klebsiella pneumoniae*. Midstream urine collection may be the preferred choice for collection for most patients; however, there are patient populations and clinical scenarios where a more invasive method of collection is preferred. All of these issues can produce incorrect culture results, misdiagnosis, especially in asymptomatic patients, poor patient management, including the use of inappropriate or ineffective antibiotics, and potentially more complicated urinary tract infection in the long term.

Qualifying Statements

Qualifying Statements

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Agency for Toxic Substances and Disease Registry (CDC/ATSDR).

Future Research Needs

The findings of this systematic review highlight the lack of recent high-quality studies that evaluate components of the preanalytical phase of urine culture. For example, the relative paucity of rigorous studies evaluating methods of storage and chemical preservation of urine specimens is troublesome considering the widespread use of these practices in many laboratories and a general consensus among microbiologists as to their benefit. A large number of the studies suffered from small sample sizes, limiting the precision of the results and reducing the likelihood that findings are applicable across a larger population. Studies also used various or unclear definitions of contamination or positivity thresholds, making meta-

analysis or qualitative summary analysis problematic. Studies further suffered from missing data. For example, most studies were cross-sectional or otherwise observational (without randomization) in design, but many, particularly those retrospective in nature, did not obtain or report the results of samples from all patients obtained by all collection methods under study. These inconsistencies lead to significantly uneven comparison groups in some cases.

Refer to the original guideline document for additional information on future research needs.

Refer also to the "Limitations" section in the original guideline document.

Implementation of the Guideline

Description of Implementation Strategy

Feasibility of Implementation

The methods of specimen collection and handling covered in the review are feasible in all settings and patient populations and are, in fact, commonly used in most medical environments today. There are data showing the benefit of either refrigerating or chemically preserving urine samples that are not immediately processed. Furthermore, midstream urine collection, with or without cleansing, is common practice for most clinical settings and patient populations. For facilities that have historically paid little attention to the preanalytic aspects of urine culture, there may be some resistance on the part of patients and staff that is typically associated with quality improvement initiatives. Appropriate education regarding the proper collection of urine specimens may be needed for both patients and health care workers. The additional costs associated with chemical preservatives, such as boric acid, would also need to be budgeted and justified.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Staying Healthy

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

LaRocco MT, Franek J, Leibach EK, Weissfeld AS, Kraft CS, Sautter RL, Baselski V, Rodahl D, Peterson EJ, Cornish NE. Effectiveness of preanalytic practices on contamination and diagnostic accuracy of urine cultures: a Laboratory Medicine Best Practices systematic review and meta-analysis. Clin Microbiol Rev. 2016 Jan;29(1):105-47. [69 references] PubMed

Adaptation

Not applicable: the guideline was not adapted from another source.

Date Released

2016 Jan

Guideline Developer(s)

American Society for Microbiology - Professional Association

Centers for Disease Control and Prevention - Federal Government Agency [U.S.]

Laboratory Medicine Best Practices - Independent Expert Panel

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Guideline Committee

Laboratory Medicine Best Practices (LMBP) Preanalytic Practices on Contamination and Diagnostic Accuracy of Urine Cultures Expert Panel

LMBP Workgroup

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Financial Disclosures/Conflicts of Interest

The authors declare no conflicts of interest.

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the Clinical Microbiology Reviews Web site.

Availability of Companion Documents

The following is available:

- Christenson RH, Snyder SR, Shaw CS, Derzon JH, Black RS, Mass D, Epner P, Favoretto AM, Liebow EB. Laboratory Medicine Best Practices: systematic evidence review and evaluation methods for quality improvement. Clin Chem. 2011 Jun;57(6):816-25. Available from the Clinical Chemistry Web site.

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on December 30, 2016. The information was not verified by the guideline developer.

Copyright Statement

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